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THE RELATION OF MOTOR POWER TO INTELLIGENCE.¹

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The application of the theory of evolution to the field of motor development has received wide recognition in the literature of several lines of investigation, and may be looked upon as one of the most vitalizing conceptions that has come into modern physiology, psychology and pedagogy. The theory of motor development is the product of it. The first suggestions of this came from Ross,² who, in his 'Diseases of the Nervous System,' distinguished between what he called the fundamental and the accessory among the muscles of the human body. Hughlings-Jackson followed up this suggestion by his doctrine of three levels in the development of the nervous system, which he applied in the interpretation of different forms of nervous and mental diseases.³ Recent applications of these suggestions have been made in the fields of psychology. For the opening up of this line of investigation we are chiefly indebted to President W. L. Bryan and Professor John A. Hancock.⁴ These investigators furnished experimental proof of what had been suggested on the side of nervous diseases. Further evidences have been found in other lines of work. The study of cell development, investigations relating to brain

¹ This work was done in the psychological laboratory of the University of Nebraska. Mr. Thomas F. Butcher, principal of the High School at Ashland, Neb., assisted in taking the observations. To his patience and skill in managing children much of the success of the work is due.

² Ross: Diseases of the Nervous System. London.

³ Hughlings-Jackson: Med. Chir. Trans., 1872.

⁴ W. L. Bryan: On the Development of Voluntary Motor Ability. *Amer. Jour. Psych.*, Vol. V, p. 125.

F. B. Dresslar: Some Influences that affect the Rapidity of Voluntary Movements. *Am. Jour. Psych.*, Vol. IV, p. 514.

J. A. Hancock: A Preliminary Study of Motor Ability. *Ped. Sem.*, Vol. III, p. 3.

localization, observations upon the process of degeneration in old age, and in progressive paralysis, and more extended experimental studies all confirm the hypothesis that motor power is a matter of slow growth, and that full maturity is reached only after growth in stature is complete.

The theory of motor development may be stated in some such form as this. The muscles of the human body are not all equally important and fundamental; they form a graduated series, with the most fundamental at the one extreme, and the most accessory at the other. The order of development is from the fundamental to the accessory. The most fundamental develop and become functionally active first, and the others in the order of their importance afterwards, the most accessory coming to full maturity late in life. Motor power is not a simple phenomenon; it is capable of being analyzed into a number of elements, the most important of which are rapidity of voluntary control, steadiness and precision of movement, variety of actions, and quickness, strength, and endurance of contraction. Development does not take place in all these respects at the same rate, nor are they all of equal importance. Some of them may be more easily experimented upon than others, and the ease of experimentation depends upon the kind of reagents that are chosen. The strength of grip, for instance, is most easily experimented upon, but the results are subject to the widest variations through practice and accidental causes, so that it is very difficult to say when a probably valid result has been obtained. Measures of endurance are equally variable. Quickness of movement requires a complicated apparatus, and that makes statistical work impracticable. No one seems to have found a method of measuring the variety of actions of which any member, or group, is capable. So that, for studies of motor power only three factors remain which can be easily studied with confidence that the results for all subjects are fairly uniform and comparable; these are rapidity of voluntary control, and steadiness and precision of movement. Great difficulties are undoubtedly encountered in investigations of these, and the observations leave much to be desired in the way of uniformity and general trustworthiness; but still we feel a fair degree of confidence that the final outcome will be

a close approximation to the real status of the persons examined.

The application of this theory to feeble mindedness and arrested growth was but a short step, and observations were soon made showing that defective children differed from the normal chiefly in their power to move. Mental development and motor power go hand in hand. From this general statement the passage is easy to the supposition that tests of motor power may be used as measures of intelligence or mental alertness. Schoolmen have long discredited the old-fashioned methods of examinations, and the examinations are slowly giving way to the prevailing distrust. The search for a substitute for the examination—for there is a real need for something of the kind, more than the mere criterion of age, in classifying pupils in the schools,—has not been rewarded by great success. The demand calls for a method of classifying pupils that will take account as well of the natural aptitude or capacity of the pupil for learning as of the attainments already made. Tests of physical endowment and of general healthfulness of body seem to offer the most promise of finding what is wanted.

As a consequence of these general suggestions, application was made to the Superintendent of Schools in Lincoln, Nebraska, for opportunity to try certain well-known, and some new, tests upon the children of the public schools. Two classes of children were chosen: those from the best wards in the city, where the general home surroundings were the most wholesome and cultivated, and others from the lower wards, where the largest percentage of poor foreigners is to be found, and where the hygienic conditions of the home as regards food, clothing, sleeping, air, and light are bad. Lincoln is what might be called a country city. The best people are good representatives of the best class of Americans, and the poor people are a mixture of various nationalities of foreigners, mostly Russian Germans. There is no real tenement or slum class, whose poverty is squalid and distressing. The children are American born, and the worst that can be said of the parents is that they do not know how to live and are indifferent to a comfortable standard. When the College Settlement was started among the people, they took interest and showed improvement.

Tests of rapidity of voluntary control, of steadiness in standing, and of steadiness and precision in moving either hand, were chosen as those most easily made, because most quickly learned through imitation, and most likely to give trustworthy results. They seem, also, to give less fluctuating results in successive trials than do other tests. For the first test an old clock fitted with a key for tapping with the finger was used. It was very similar to the one used by Bryan in his test of the school children in Worcester, Mass. Each child was given five trials with either hand to find the number of taps that could be made in five seconds. The child was shown how to do the work, and then allowed to make a trial with either hand before the actual observations were taken. In taking the five trials the hands alternated.

For testing the precision and steadiness in moving either hand, a new apparatus was constructed. It consisted of a number of strips of brass one-half inch wide, and eight inches long. These were arranged parallel to one another at different distances apart, and were all connected with one pole of a battery. They were fastened only at the ends so that a needle set in the end of a glass rod might be passed between them. The needle was connected with the other pole of the battery and a relay signal placed in the circuit. When the needle was brought into contact with the brass, this fact was indicated by the signal. The several distances between the brass strips were one-half, three-eighths, one-quarter, and one-eighth of an inch. The test consisted in passing the needle successively through these openings, beginning with the widest, from one end to the other, either downward, upward, to the right or to the left, and with both hands, the hands being alternated in the several trials to avoid fatigue. The record was kept in the number of times the relay signal sounded, indicating contact between the needle and the brass. With some children the amount of unsteadiness was considerable, so that the figures representing the number of contacts are not entirely accurate, because the sounds could not always be readily counted. The disturbance caused by the relay signal may be avoided by holding the fingers upon the poles of the signal and thus receiving the shock through the hand. If the battery is not strong the

successive shocks can be easily counted, but the child needs to know by the sound as well as by sight that the needle rests against the brass.

For the third test steadiness in standing was chosen. The ataxiagraph devised by Crichton-Browne,¹ and used by many others, was employed. This instrument has been used more often as a test of nervous health and strength than of motor power. For the former purpose it is probably better adapted, as some of our observations will show, and yet nervous weakness is so much a matter of slow and imperfect growth that most diseases of the nervous systems in children may be regarded as simply manifestations of a disturbance of the processes of development. If this be a true statement of the case, then, where the instrument shows a lack of nervous control, the subject may be looked upon as a case of slow growth or retarded development. However, cases of manifest nervous and mental weakness show certain characteristics that are not clearly found in any of the stages of motor development. This matter will come up again when a discussion of the observations themselves is reached.

The purpose of the experiment was to determine whether tests of motor power showed the same backwardness and deficiency which had already become apparent in the school work. About sixty children from the lower wards were tested and compared with an equal number from the best families in the best wards. In the following table will be found the distribution, according to grade in school work, of the children examined.

Grade.	1st.	2nd.	3rd.	4th.	5th.	Grade not known.	Total.
Poor children,	24	15	7	—	—	13	59
Good “	—	6	27	15	4	—	52

This shows that the better children average just about two grades higher than the poorer. Among the poorer a class of ‘grade not known’ is given. This includes those children who did not know their grade. When inquiry was made of the teachers we were told that a considerable number of children had been in the school several years, making little or no progress, so that they were practically without grade. Such chil-

¹ Crichton-Browne: *The Nervous System and Education*. London.

dren were simply allowed to stay in school, as the school was a better place for them than the street; besides, the law prescribes that they shall be sent to school. The teachers deal with them in the best way they can, but have little hope of their making any progress. These children, with four exceptions, reported their ages as either eight or nine years. Some of them were quite uncertain about it, and not a few found difficulty in understanding what was wanted when the ages were asked for. No attempt was made to pick out the poorest among those found in the lower ward schools; all the children in the school who could be persuaded to take the tests were examined. A number who were manifestly weak and feeble were rejected, and several others seemed so dull that they could not be made to understand what was wanted of them. Their attention could not be kept upon the work long enough to get satisfactory tests. Some allowance must be made for a few because they did not readily understand the English language; yet where they were reasonably bright, they understood quickly through imitation what was expected of them.

The following table gives the results of the tapping tests. It appears in three parts: the first shows the comparisons between the right and left hands of pupils of the same age and of the classes good and poor; the second shows the comparisons between the good and poor of the same ages and for the right and left hands; and the third shows the comparisons between pupils of eight and nine years of age for the classes good and poor and for the right and left hands. As stated above, five trials of the number of taps that could be made in five seconds of time were taken. The figures in the separate columns represent the average number of taps for the pupils without regard to grade or sex. 'R. H.' and 'L. H.' stand for right and left hands respectively.

TABLE I.
Tapping Experiment. First Part.

Trials.		1st.	2nd.	3rd.	4th.	5th.
Good.	9 yrs. R. H.	29.76	30.21	30.31	30.93	31.39
"	" L. H.	26.48	26.90	26.93	26.68	26.80
Difference		3.28	3.31	3.38	4.27	4.59 = 8.83

Trials.		1st.	2nd	3rd.	4th.	5th.
Good.	8 yrs. R. H.	27.60	28.80	28.50	28.80	29.00
"	" L. H.	24.00	24.20	24.90	24.00	24.80
Difference		3.60	4.60	3.50	4.80	4.20=20.80
Poor.	9 yrs. R. H.	26.42	28.50	28.08	27.75	27.00
"	" L. H.	24.95	23.67	23.73	23.36	23.12
Difference		1.47	4.83	4.35	4.39	3.88=18.92
Poor.	8 yrs. R. H.	26.25	27.75	26.83	27.91	27.40
"	" L. H.	23.33	23.17	24.16	23.10	23.44
Difference		2.92	4.58	2.67	4.81	3.96=18.94

Second Part.

Good.	9 yrs. R. H.	29.76	30.21	30.31	30.93	31.39
Poor.	" "	26.42	28.50	28.08	27.75	27.00
Difference		3.34	1.71	2.24	3.18	4.39=14.85
Good.	9 yrs. L. H.	26.48	26.90	26.93	26.68	26.80
Poor.	" "	24.95	23.67	23.73	23.36	23.12
Difference		1.53	3.23	3.20	3.32	3.68=14.96
Good.	8 yrs. R. H.	27.60	28.80	28.50	28.80	29.00
Poor.	" "	26.25	27.75	26.83	27.91	27.40
Difference		1.35	1.05	1.67	.89	1.60= 6.46
Good.	8 yrs. L. H.	24.00	24.20	24.90	24.00	24.80
Poor.	" "	23.33	23.17	24.16	23.10	23.44
Difference		.67	1.03	.74	.90	1.36= 4.90

Third Part.

Good.	9 yrs. R. H.	29.76	30.21	30.31	30.93	31.39
"	8 " "	27.60	28.80	28.50	28.80	29.00
Difference		2.16	1.41	1.81	2.13	2.39= 9.90
Good.	9 yrs. L. H.	26.48	26.90	26.93	26.68	26.80
"	8 " "	24.00	24.20	24.90	24.00	24.80
Difference		2.48	2.70	2.03	2.68	2.00=11.89
Poor.	9 yrs. R. H.	26.42	28.50	28.08	27.75	27.00
"	8 " "	26.25	27.75	26.83	27.91	27.40
Difference		.17	.75	1.25	-.16	-.40= 1.61

Trials.				1st.	2nd.	3rd.	4th.	5th.
Poor.	9 yrs.	L.	H.	24.95	23.67	23.73	23.36	23.12
"	8 "	"	"	23.33	23.17	24.16	23.10	23.44
Difference				.62	.50	.43	.26	-.32 = .61

Let us look at the first part of the table. The figures at the right of the table, representing the sums of the differences for the five successive trials when the right and left hands are compared, show that there is about the same difference between the hands for both good and poor at both ages—eight and nine. The hands of the eight year old children tend to differ more than those of the nine year old. This may, however, be only accidental, as the differences are too small to place any reliance upon. In the second part, where the comparison is made between the good and the poor, some interesting results are shown. The good children of nine years of age both with the right and left hands differ more strikingly from the poor of the same age, than the good of eight years do from the poor of the same age. The figures that represent these differences are 14.85 for the right and 14.96 for the left hand for the nine year old children and 6.46 for right hand and 4.90 for left hand for the eight year old children. The difference which is small at eight is increased at nine, and had the tests been carried farther we might reasonably expect a still wider difference. A few children of ten years could have been got, but most children who make no progress in school work by that age become irregular in attendance and finally drop out. It may be that some significance is to be attached to the fact that at eight years of age the right hands of the good and poor differ more than the left hands do. This is shown by the difference between 6.46 and 4.90. The fact that the good and poor differ more at nine years of age than at eight years shows clearly the phenomenon of arrested growth.

In the third part of the table is found the comparison of ages. The first point to be noted is that the differences which have been found between hands in the first part and between the good and poor in the second part of the table are much less in the third part where ages are compared. Age differences count less than the other differences. The nine year old children in the class of good differ from the eight year old children

in the same class by 9.90, when the right hand is used and by 11.89 when the left hand is used, while the nine year old children in the poor class differ from the eight year old by 1.61 when the right hand is used and by .61 when the left hand is used. That is, the older children in the good class differ greatly and more from the younger than they do in the poor class. This, again, shows clearly the phenomenon of arrest.

The backwardness of these children may perhaps be better seen in the way in which each is affected by practice and by fatigue. Capacity for growing under practice, could it be readily and expeditiously tested, would seem to furnish the desired test of mental weakness. Indeed, practice effect is really the thing aimed at by educational processes. The ability of a child to take on new habits represents educability. The old and young differ most in just this respect. Backwardness may be treated simply as premature old age, or the failure in the natural plasticity that characterizes youth. The stupid child that cannot learn, possesses no capacity for being affected by practice.

While our tests do not furnish all that could be desired in this respect, they do cast some light upon the question. The five successive trials at tapping furnish opportunity for making some test of the capacity for practice effect. This may be done by computing the average trial gain or loss. The method employed here was to subtract the average for the first trial in order from averages for the subsequent trials, and then to treat each average in the same way for all subsequent trials. The differences thus obtained were added, and divided by the number of times the actual trial difference had been taken. The comparisons which appear in the following table are for the right and left hands of the good and poor without reference to age. The average trial practice gain or loss stands at the right.

TABLE II.

	1st.	2nd.	3rd.	4th.	5th.
Good. R. H.	29.60	30.29	30.52	30.70	31.20 = .361 gain
" L. H.	25.57	25.41	26.59	26.30	26.49 = .269 gain
Poor. R. H.	26.85	27.35	27.25	27.40	26.78 = .09 loss
" L. H.	23.75	23.66	23.78	23.87	23.58 = .11 loss

The right hands of the good children show an average trial practice gain of .361, and the left hands of .269; both the hands of the poor children show a very small average practice loss. That the left hands should not respond as quickly as the right is to be expected; but the fact that bright children show greater effects of practice is new and significant. It proves the fatigue-ability of the poor children. The children complained frequently of their arms being tired, in which case they were given an interval for rest, although the hands were alternated so that the one might rest while the other was at work. The feelings of fatigue, however, are often of central origin, and the brain worked in much the same way while either hand was doing the tapping. The extreme awkwardness of these children was most characteristic. Again, some of them were very suggestible. Inquiry was made about their food, whether they drank coffee and tea; and not infrequently they would answer both 'yes' and 'no,' according as the form of the question was changed from positive to negative. Some of them were so inattentive that it was with difficulty the observations could be made at all. This seemed to be due to fatigue; for seven or eight of them grew so tired that they asked to leave off the tapping after two or three trials. This could not have been due to mental disturbance, for they took up other tests. Another significant fact was that they tapped rhythmically. Many of them seemed able to make taps rapidly enough, but they could not execute more than eight or ten taps until they made a stop, or slowed up, and then went on with a fresh effort. Five seconds does not seem to be too long a time for a child to keep up a muscular effort but for these poor children it is plainly too long, and this indicates their weakness. We are inclined to believe that capacity for practice and fatigue-ability stand in an inverse ratio to one another. Practice increases the power to resist fatigue, and also accelerates the rate of recovery from it. In summing up, it can be said that capacity to grow through practice, and the power to resist fatigue, are accompaniments of intellectual brightness and form one test of mental strength.¹

¹ These facts are clearly brought out in unpublished work done in the Psychological Laboratory at the University of Nebraska.

Although the numbers of the children are rather small, we will nevertheless offer a comparison of the boys and girls with both the right and left hands. This will be found in the table following.

TABLE III.

Girls. Good. 9 yrs. R. H.	30.1	30.6	30.7	31.0	31.6
Boys. " " "	29.9	30.1	30.2	31.1	31.2
Difference	.2	.5	.5	-.1	.4 = 1.5
Girls. Good. 9 yrs. L. H.	26.8	27.8	27.8	27.0	27.1
Boys. " " "	26.1	25.8	27.1	26.4	26.5
Difference	.7	2.0	.7	.6	.6 = 4.6
Girls. Poor. 9 yrs. R. H.	28.5	28.5	28.3	28.4	29.0
Boys. " " "	27.0	28.	27.7	28.0	27.3
Difference	1.5	.5	.6	.4	1.7 = 4.7
Girls. Poor. 9 yrs. L. H.	25.2	23.9	24.7	25.1	24.9
Boys. " " "	24.1	24.6	24.0	23.9	24.0
Difference	1.1	-.7	.7	1.2	.9 = 3.2

These figures show that the girls are uniformly better than the boys. The girls in the good class do not show greater or even quite as much superiority over the boys of the same class, as the girls of the poor class show over the boys of the same class. The common opinion that backwardness or mental arrest takes a deeper hold upon boys than upon girls is, therefore, supported by a small margin, but it is too small to be given any emphasis.

We pass now to a consideration of the tests of precision and steadiness in movement. Four movements with either hand were made, and two trials with each hand for all four movements were allowed. These movements were either upward or downward in vertical direction, or toward the median plane or away from it in the horizontal direction. 'Toward the median plane' means a contraction of the arm, and 'away from it' an extension of the arm. The first is probably the more primitive and useful. The second, particularly with the right hand of right handed persons, is an acquired movement, much used in writing and drawing. We might expect that, since it is so frequently used, it would be the more precise and

steady; but this is by no means the case. Social customs have little power to modify fundamental movements that have been fixed by selection through heredity. Let these two movements be called respectively the inward and outward movements. The inward movement for both hands is always more steady than the outward. The difference between the inward and outward movements for the right hand is slightly less than for the left hand, showing that social customs may have affected slightly the precision of the outward movement through practice. This will appear in the table following. The figures represent the average number of times the needle came into contact with the metal in passing between the strips of brass. R. H. means right hand, and L. H. left hand.

TABLE IV.

Good children. 9 yrs.			
R. H. moving outward	18.04	L. H. moving outward	22.87
R. H. " inward	<u>15.93</u>	L. H. " inward	<u>18.78</u>
Difference	2.11	Difference	3.09
Good children. 8 yrs.			
R. H. moving outward	19.36	L. H. moving outward	27.21
R. H. " inward	<u>17.71</u>	L. H. " inward	<u>19.93</u>
Difference	1.65	Difference	7.28

When a child was asked to draw a straight line, or indicate how steadily he could move his hand, he invariably moved the hand outward. In this, of course, he follows social custom, and yet that does not mean the highest skill. This suggests that perhaps human beings possess biological possibilities of movement that we know nothing of, and that these will enormously increase our social efficiency when they have been discovered. Scarcely a day passes, now, that something new in this line is not brought to light.

We propose now to show that these tests prove much the same distinction between the good and the poor that the former test with the tapping apparatus has shown. In the following table a comparison will be made with respect to classes, good and poor, and with respect to age.

TABLE V.

Part I. Comparison of the good with the poor.

		RIGHT HAND.				LEFT HAND.			
		In.	Out.	Down.	Up.	In.	Out.	Down.	Up.
Good.	9 yrs.	15.93	18.04	19.59	24.91	18.78	22.87	24.50	28.93
Poor.	" "	25.15	27.23	28.00	36.92	30.08	30.69	33.69	37.23
Differences		9.22	8.19	8.41	12.01	11.30	7.82	8.19	8.30
Good.	8 yrs.	17.71	19.36	22.00	27.21	19.93	27.21	26.91	29.71
Poor.	" "	21.87	25.87	26.93	32.67	25.40	29.13	30.80	35.53
Differences		4.16	6.51	4.93	5.46	5.47	1.92	3.89	5.82

Part II. Comparison between the ages.

Good.	9 yrs.	15.93	18.04	19.59	24.91	18.78	22.87	24.50	28.93
"	8 "	17.71	19.36	22.00	27.21	19.93	27.21	26.91	29.71
Differences		1.78	1.32	2.41	2.30	1.15	4.34	2.41	.78
Poor.	9 yrs.	25.15	27.23	28.00	36.92	30.08	30.69	33.69	37.23
"	8 yrs.	21.87	25.87	26.93	32.67	25.40	29.13	30.80	35.53
Differences		3.28	1.36	1.07	4.25	4.68	1.46	2.89	1.70

In the first part of the table the figures designating differences represent the superiority of the good children over the poor. When these figures representing the difference between the good and poor are compared with the corresponding figures in the second part, representing the differences between the ages, it will be seen that they are much larger. It has already been shown that the good children stand on the average two grades in school work above the poor. The tests here would indicate an equally large difference in motor power. If now the difference between the good and poor at nine years of age be compared with the difference at eight years of age, it will be noticed that the nine year old children among the good show a greater superiority over the poor than they do at eight years of age. This was pointed out before and the difference now becomes still more apparent. This is best seen in the second part, where the comparison between ages is given. Nine year old children among the good are superior to the eight year old, as we should expect; but among the poor class the eight year old children are as much superior to the nine year old as the nine year old in the good class are superior to the eight year

old of the same class. The difference is simply reversed. This is to be accounted for in part by the fact that the nine year old children of the poor class represent those pupils in the public schools who have gone a number of years and have not been promoted. A nine year old child who has not made more than the second grade is to be accounted very backward. By that age the child begins to feel his defect, loses heart, and begins to think of leaving school. Such children are in the depression that precedes adolescent growth, and this falls with especial severity upon those that are poorly endowed. Among the eight year old children are some well endowed children, who, through accidents, are behind in their school work, and they help to bring up the general averages of the class. The school from which most of the poor children were taken contained only three grades, and most of these pupils were in the first two grades. The bright children were sent from here to other buildings after they reached the third grade. Those that did not get on rapidly were retained, and nominally advanced to a third grade, in which, for the most part, they did not do well.

A comparison of the boys and girls of nine years of age, upon the basis of this test, yields much the same result as was obtained in the tapping test. The figures are given in the following table.

TABLE VI.

		RIGHT HAND.				LEFT HAND.			
		In.	Out.	Down.	Up.	In.	Out.	Down.	Up
Good.	Boys 9 yrs.	22.9	22.7	19.2	19.5	25.3	24.8	24.0	22.3
"	Girls "	16.8	18.5	17.1	20.6	21.4	23.4	22.8	24.8
	Difference	6.1	4.2	2.1	-1.1	3.9	1.4	1.2	-2.5
Poor.	Boys 9 yrs.	20.8	23.2	23.1	28.3	24.5	27.0	28.0	31.2
"	Girls "	17.3	19.3	20.5	24.5	21.1	26.3	27.5	30.9
	Difference	3.5	3.9	2.6	3.8	3.4	.7	.5	.3

The tests with the ataxiagraph were the least satisfactory of all. The instrument cannot be made with sufficient mechanical accuracy. The test, like that of the dynamometer, has a most general import. It is more severe upon the pupils in the way of a nervous strain; they do not see the meaning of it; and no interest can be aroused, either through suggestion or

through mutual rivalry. The results are appended without emphasis. The figures represent the amount of swaying of the body in mm. in the anterior-posterior and lateral directions.

TABLE. VII.

	Ant. Post.	Lateral.
Good	16.2 mm.	11.7 mm
Poor	18.8 "	12.4 "
	<hr/> 2.6 "	<hr/> .7 "

This indicates a small difference in favor of the good. A number of children that were plainly weak were tested, and they swayed more in the lateral than in the anterior-posterior direction. This has been pointed out before as a symptom of nervous weakness. The movement in the anterior-posterior direction was very generally forward. The amount of movement was measured by laying two carpenter's squares together in such a way as to form a quadrilateral that would enclose all the markings of the writing point. The distances were then read off directly upon the corners of the squares. This takes no account of the actual amount of swaying, only of the extreme limits within which swaying took place.

We must decide against the ataxiagraph, as an instrument that is unadapted for finer psycho-physical measurements. The tapping test and the test of precision and steadiness in moving seem to us, when made with care and patience, to yield fairly trustworthy results. A number of observations upon each pupil, under skillful management, is always required and the outcome will be indicated not so much by the absolute value of the figures obtained as by the indication they give of gain through practice or of the resistance offered to fatigue. The curve of practice must first be determined, before the value of any observation can be determined, and influences must be studied by the way in which they affect the curve of practice.

These tests have shown that with the brighter children motor power increases with advancing age. There is greater rapidity of motion, increased steadiness and nicer precision, the older the children grow. Backwardness, slowness of growth and arrest of development are indicated by pupils through their

inferiority to their fellows of the same age in some or all these respects. The explanation of motor development is based upon the growth of interrelations among nerve elements. Cells put out processes, which extend sometimes considerable distances in all directions throughout the nervous system. These processes place the cells in communication with many of their neighbors, so that when they are thrown into activity their neighbors must act; and many cells or groups of cells acting simultaneously make possible precise, rapid, and nicely adjusted movements. The number of cells does not change, probably, after foetal life, subsequent change being due always to increasing connections between isolated ganglia. Arrest of growth is thus confined entirely to a suspension in the growth of associative connections.

The relation of mental to motor development finds its explanation in something like this: The movements of the voluntary muscles are felt in consciousness; in fact, the possibility of a voluntary movement depends upon the consequences of the movement being felt. The greater the variety of movements that can be performed, the more precise they are, the more steady and rapid, the greater the fund of sense experience they will yield up to consciousness, out of which are to be built the various products of mental activity. Every new movement acquired adds a new piece of furniture to the mental household. Movement may not be the sole source of mental representations, but representations of movements do enter into our mental constitutions, so that the higher our motor development has progressed, the more will our consciousness be built up from this source.

Mind, whatever its metaphysical nature may be, is a device to aid us in getting on in the world of things; minds are to direct activity and to control conduct. Our organisms are so constructed that impressions made upon the sense organs tend to issue in motions. The purpose of sensation is, then, that movement may be directed. These movements are protective and preservative of the organism, and it is thus for the sake of movement—conduct in the large sense—that mind exists. Accordingly mind and movement must develop together; for without movement there is no mind. In so far forth as an individ-

ual is wanting in motor development, he is wanting in mental development. The aim of all instruction for the feeble minded is to awaken movement; when that has been accomplished, mental development will take care of itself. This has an important bearing upon the beginning of educational work. Nature has pointed out the way, by filling the young of higher animals with impulses to act, following which they discover shortly in their plays most of their possibilities for acting. Much has been accomplished, when it has been shown that lack of mental alertness and intellectual brightness is accompanied by a deficiency in motor power; and the goal will have been reached when accurate tests have been found, which shall indicate the degree of this deficiency. The further problem is a practical one, first, to find methods of awakening and developing motor power, and second, where the deficiency is proved to be permanent, to find an education that is suited to the needs of the defective.